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AUTHOR Iaccino, James F.; Sowa, Stephen J.
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ABSTRACT

Since past studies have shown that females as well as left-handers do not demonstrate a right-ear advantage for verbal materials, suggesting that linguistic functions may not be handled in the left hemisphere exclusively, a study was conducted to examine these laterality effects more closely. Subjects, 24 undergraduate students at a small college in Illinois, were divided equally into groups according to sex and hand dominance. Experimental instructions as to which ear to focus on were provided in a dichotic listening procedure, with left-ear attendance required in the first block of trials and right-ear in the final set. Results indicated an interaction between sex and instructions--with males performing better than females when asked to attend to the right ear, highlighting the importance of information processing strategies in asymmetrical performance. It still remains to be determined whether males have a more linguistically oriented left hemisphere or are more effective task demand followers than females. (A table of data is included, and 55 references are attached.) (ARH)

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Cerebral Asymmetries in the Processing of Dichotic Materials as a Function of Sex, Handedness, and Instructions

James F. Iaccino and Stephen J. Sowa

Illinois Benedictine College

Running head: CEREBRAL ASYMMETRIES

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Abstract

Past studies have shown that females as well as left-handers do not demonstrate a right-ear advantage (REA) for verbal materials, suggesting that linguistic functions may not be handled in one hemisphere exclusively (i.e., the left). To examine these laterality effects more closely, our subjects were equally divided in sex and hand dominance. Moreover, experimental instructions as to which ear to focus on were provided in a dichotic listening procedure, with left-ear attendance required in the first block of trials and right-ear in the final set. Results indicated an interaction between sex and instructions—with males performing better than females when asked to attend to the right ear, highlighting the importance of information processing strategies in asymmetrical performance. It still remains to be determined whether males have a more linguistically oriented left hemisphere or are more effective task demand followers than females.

Cerebral Asymmetries in the Processing of Dichotic Materials as a Function of Sex, Handedness, and Instructions

Ever since classical times, it has been claimed that the human brain is composed of two physiologically equivalent halves, the left hemisphere and the right hemisphere. More recently, we have learned that each half regulates movement in the opposite side of the body. Interestingly, by the end of the nineteenth century, physicians were beginning to postulate that higher cognitive functions might be organized asymmetrically in the left and right hemispheres. That is, the left cerebral hemisphere apparently was more specialized for language functions whereas the right hemisphere was more critically involved in the perception and recall of spatial material and less so with verbal information (Bradshaw & Nettleton, 1983; Kimura, 1973; Kinsbourne, 1978; McGlone, 1980).

By the early 1960s, experimental psychologists were assessing hemispheric specialization in the laboratory. One such procedure employed was the dichotic listening task, in which subjects heard sets

of stimuli that were presented to both ears simultaneously and then had to report as many of the sounds back to the experimenter as accurately as possible. A right-ear (or left hemisphere) superiority was found for verbal materials, as measured by more correct identifications in that particular ear, and a left-ear (or right hemisphere) dominance was shown for musical stimuli as well as other nonlinguistic sounds (Curry, 1967; Kimura, 1961, 1964, 1967).

Based on these research findings, one might infer that verbal and spatial functions are mediated by the left and right hemispheres exclusively. However, several cautions need to be mentioned when interpreting hemisphere effects. First, a left-right auditory difference does not necessarily reflect a corresponding left-right asymmetry across cerebral hemispheres. It should be remembered that each ear is actually connected to both hemispheres, and so both halves are involved in the processing of any type of material.

A second major point to be considered is that not all subjects have the same type of hemispheric organization (see Bryden, 1982; Kinsbourne, 1978). Levy

(1972) and Harris (1978) propose that females are less lateralized for speech than males due to their representing language in both hemispheres by the time they attain early adulthood. To confirm this argument, one of the largest studies on dichotic listening was executed by Lake and Bryden (1976). Their findings revealed a pronounced right-ear advantage (REA) for consonant-vowel combinations only in adult males, suggesting greater lateralization of verbal functions with this respective group. Similar listening designs have consistently replicated these results (Bryden, 1966; Harshman, Remington & Krashen, 1975; Knox & Kimura, 1970; McGlone & Davidson, 1973; Thistle, 1975), in further support of the bilateral speech mechanism attributed to females.

Reduced (to reversed) asymmetries and even symmetrical trends have also been obtained with left-handers in dichotic presentations (Annett, 1982; Bradshaw, 1980; Bryden, 1970, 1975; Curry, 1967; Curry & Rutherford, 1967; Dee, 1971; Galaburda, LeMay, Kemper, & Geschwind, 1978; Hicks & Kinsbourne, 1978; Knox & Boone, 1970; Satz, Achenbach, Patishall, & Fennell, 1965; Witelson, 1980). Levy (1969) accounts for these

differences between sinistrals and dextrals by explaining that left-handers are able to represent verbal functions in both hemispheres, similar to the bilateral organization present in females. Because of this linguistic symmetry, right-hemispheric spatial processing should be disrupted and in fact, poorer performance of sinistrals has been evidenced in non-verbal tasks (Levy & Reid, 1978; Miller, 1971; Nagae, 1985a; Nebes, 1971; Nebes & Briggs, 1974; Yen, 1975).

Moreover, a limited number of studies have shown a sex-hand interaction, namely, that left-handed female subjects are at the greatest disadvantage when it comes to demonstrating spatial competencies (Levy, 1976; McGlone & Davidson, 1973; Sanders, Wilson, & Vandenberg, 1982). It would appear that sex and handedness effects need to be examined together in greater detail to determine whether sinistral women show the greatest symmetries (in tasks that are of a more verbal nature).

Beside the varying cerebral organizations in specific groups, Bryden (1978, 1980a, 1980b) has identified a possible confounding factor that can be contributing to the observed laterality in dichotic listening procedures: attentional bias. In his

experiments, Bryden instructed subjects to listen to input coming through one ear only (i.e., right or left) and then allowed them to report only items on that given side. Subjects were also required to shift their attention to the "unfavored" ear on alternating blocks of trials in order to improve their accuracy on the previously unattended side. Results not only revealed a striking REA, but also a more stabilized laterality effect for individuals in the "focused attention" group, in comparison to those who were simply told to divide their attention between both ears. These findings and others (Garabedian, Schwartz, & Dean, 1982; Kinsbourne, 1970, 1973, 1975) suggest that instructions provided in auditory tasks might have a direct influence on asymmetric outcomes.

The present experiment investigated the effects of sex, handedness, as well as instructions on the processing of dichotic input. Our major predictions were that: symmetries would be most pronounced in left-handed females, and that the "attend" instructions would presumably have their greatest impact on asymmetrical performance in dextral males, with the strongest laterality being evidenced here.

Method

Subjects and Design

The subjects were 24 undergraduate students of Illinois Benedictine College in Lisle, Illinois who received extra-credit points in an Introduction to Psychology class for their voluntary participation. This group consisted of an equivalent number of left- as well as right-handers, with sexes being evenly distributed. Based on this group division, a 2 X 2 X 2 mixed factorial design was used to analyze correct ear identifications within the dichotic listening task, with sex (male, female) and handedness (left-hander, right-hander) representing the between-subject factors and instructions (left-ear attendance, right-ear attendance) representing the within-subjects factor.

Assessment of Handedness

Consistent with previous studies, Annett's (1967) handedness questionnaire was distributed to the entire psychology class to determine the hand dominance of all subjects. The twelve-item questionnaire asked subjects to judge which hand they used the most (left, right, or either) across a wide range of manual activities (e.g., brushing one's teeth, throwing a ball, writing a

letter, and unscrewing a jar). Employing Nagae's (1983) scoring procedure, the principal investigator assigned a score of -1 to every left response that was provided by each subject, a score of +1 to every right response, and a 0 to every either response that occurred. Those subjects with the strongest hand preference were subsequently chosen to participate in the main experiment. Their mean degree of hand dominance was as follows: left-handed males = -10.66 (SD = 1.73), right-handed males = 10.60 (SD = 0.81), left-handed females = -11.04 (SD = 1.26), and right-handed females = 10.80 (SD = 1.20).

Stimulus Materials and Apparatus

The dichotic sounds were basically derived from the Lake and Bryden (1976) experiment. Specifically, the stimuli consisted of single pairs of consonant-vowel (CV) syllables, with each syllable having one of six stop consonants (i.e., b, d, g, p, t, and k) paired with the vowel a. Moreover, each CV syllable was randomly matched with every other syllable four times, thus generating a total of 60 pairs for each instruction condition.

The 60 pairs were first recorded on a Maxell High-Grade VHS videotape, and then each of the pairs was

matched to within an error rate of .03 seconds via a Panasonic stereo-editing system (Model No. NV8500). The equipment allowed for proper balancing between left- and right-channels as well as effective presentation rates of the pairs every five seconds, with each pair having a 500 millisecond duration. The 60 pairs were then duplicated for the purposes of testing subjects on the same material in each ear attendance condition. Finally, the sounds were directly copied onto Maxell High-Grade cassette tapes and subsequently played to subjects at a moderate volume level through a Sanyo recorder with attached stereo headphones (Model No. M-G7).

Procedure

Using the Bryden (1978) format, subjects were told that they would be hearing a series of simple sounds which would be presented in each ear simultaneously. On the first set of 60 trials, they were instructed to focus their attention on the left ear and report only those respective sounds. On the final set of 60 trials, subjects had to shift their attention to the unattended ear (i.e., the right) and perform the necessary identifications. A one-minute rest interval was interspersed between the two instruction conditions;

this was followed by a prerecorded 45 decibel tone which announced the start of the second block of trials.

Because the dichotic pairs were presented at a rapid pace, a cued sheet containing all possible CV syllables was provided to subjects throughout the trials to assist them in their responses. To further ensure that some response would be generated on each trial, guessing was suggested as a final option only if subjects experienced difficulty in discriminating similar sounding pairs (e.g., ba-pa, ka-ga). The experimenter was then able to record two correct identification totals for each subject, based on the ear side they were required to attend to.

Results

Analysis of variance results on dichotic listening performance demonstrated main effects of sex, F (1,21) = 22.92, MS_e = .48, $p < .01$, as well as instructions, F (1,21) = 9.52, MS_e = .48, $p < .01$. In addition, a significant Sex X Instructions interaction was found, F (1,21) = 6.28, MS_e = .74, $p < .05$, which revealed that males performed better than females when they were asked to attend to the right ear.

Insert Table 1 about here

Scheffe post-hoc comparisons further showed that male identifications were influenced by the type of experimental instructions received, with left-ear attendance generating more errors than right; this pattern was not reflected in the female scores . It should be noted that the predicted hand effect did not occur nor did any interactions with this variable, seriously questioning Nagae's (1985a, 1985b) assumption that handedness was a better predictor of cerebral laterality than sex.

Discussion

Two findings are of interest in this experiment. The first is that symmetries were more pronounced in females than males (regardless of hand preference); more specifically, there was neither a REA or LEA for this sex group. Males, on the other hand, showed a definite REA for the dichotic materials, replicating the sex differences obtained in previous research (Knox & Kimura, 1970; Lake & Bryden, 1976; McGlone & Davidson, 1973). Based on this data, we might infer that females

are less lateralized for language than males, and thus have a different hemispheric organization than the latter group.

However, a viable alternative might be that the experimental demands of the auditory task (i.e., attentional bias) produced the laterality effect observed in males. The second, and more important, finding which supports this inference is that the right-ear attendance instructions exerted a positive influence on dichotic recognitions exclusively within the male group. As Bryden (1980b) suggests, males might be approaching the task with a different attentional strategy than females. They might even be more efficient task demand followers than females. This does not necessarily imply that the sexes have varying cerebral structures; rather, they have different ways of processing particular inputs based on the task requirements. One inconsistency is that Bryden (1980b) did not observe this sex effect when instructions were manipulated, only a more pronounced REA was obtained in his "focused attention" groups. However, Bryden's sample (like ours) was of an insufficient size to make any conclusive statements. We, therefore, recommend

that future studies more thoroughly investigate the effects of auditory attention (or for that matter any type of stimulus bias) on sex in order to more effectively determine whether asymmetrical performance in males is more heavily influenced by cerebral organization or task demands.

The failure to find a handedness effect was a surprising result, directly contradicting the Levy (1969) position of symmetrical organization of linguistic functions in sinistrals. Some investigators, though, have not recognized these differences between handedness groups in the verbal tasks they have employed (Johnson & Harley, 1980; Newcombe & Ratcliff, 1973; Newcombe, Ratcliff, Carrivick, Hiorn, Harrison, & Gibson, 1975; Weber & Bradshaw, 1981), so one should exercise some caution before predicting whether one variable is more closely correlated with laterality than another.

Based on these overall results, we have adopted the view that asymmetrical performance is not <u>simply</u> a function of one's sex, hand preference, predetermined brain structure, or attentional bias, but rather an interaction of all these factors plus several others

that require further examination, such as task complexity (Kimura, 1985) and maturation effects (Waber, 1976). As Fairweather (1976, 1982) advises, research should be directed toward more standardized and well thought-out methodologies that can accurately assess the relative importance of each of these variables in the processing of sensory inputs. And we agree with this sentiment whole-heartedly!

References

Annett, M. (1967). The binomial distribution of right, mixed and left handedness. Quarterly Journal of Experimental Psychology, 29, 327-333.

Annett, M. (1982). Handedness. In J. Beaumont (Ed.), Divided visual field studies of cerebral orgnization. New York: Academic Press.

Bradshaw, J. L. (1980). Right-hemisphere language: Familial and non-familial sinistrals, cognitive deficits and writing hand position in sinistrals, and concrete-abstract, imageable-nonimageable dimensions in word recognition. A review of interrelated issues. Brain and Language, 10, 172-188.

Bradshaw, J. L., & Nettleton, N.C. (1983). Human cerebral asymmetry. New Jersey: Prentice-Hall.

Bryden, M. P. (1966). Left-right differences in tachistoscopic recognition: Directional scanning or cerebral dominance? Perceptual and Motor Skills, 23, 1127-1134.

Bryden, M. P. (1970). Laterality effects in dichotic listening: Relations with handedness and reading ability in children. Neuropsychologica, 8, 433-450.

Bryden, M. P. (1975). Speech lateralization in families: A preliminary study using dichotic listening. Brain and Language, 2, 201-211.

Bryden, M. P. (1978). Strategy effects in the assessment of hemishperic asymmetry. In G. Underwood (Ed.), Strategies of information processing. London: Academic Press.

Bryden, M. P. (1980a). Attentional factors in the detection of hemispheric asymmetries. In G. Underwood (Ed.), Strategies in information processing. New York: Academic Press.

Bryden, M. P. (1980b). Sex differences in brain organization: Different brains or different strategies? Behavioral and Brain Sciences, 3, 230-231.

Bryden, M. P. (1982). Laterality: Functional asymmetry in the intact brain. New York: Academic Press.

Curry, F. K. (1967). A comparison of left-handed and right-handed subjects on verbal and nonverbal dichotic listening tasks. Cortex, 3, 343-352.

Curry, F. K., & Rutherford, D. R. (1967). Recognition and recall of dichotically presented verbal stimuli

by right- and left-handed persons. Neuropsychologia, 5, 119-126.

Dee. H. L. (1971). Auditory asymmetry and strength of manual preference. Cortex, 7, 236-245.

Fairweather, H. (1976). Sex differences in cognition. Cognition, 4, 231-280.

Fairweather, H. (1982). Sex differences: Little reason for females to play midfield. In J. Beaumont (Ed.), Divided visual field studies of cerebral organization. New York: Academic Press.

Galaburda, A. M., Le May, M., Kemper, T. L., & Geschwind, N. (1978). Right-left asymmetries in the brain. Science, 199, 852-856.

Garabedian, A. A., Schwartz, N. H., & Dean, R. S. (1982). Attention effects in auditory asymmetries. Paper presented at the 19th Annual Convention of the American Psychological Association, Washington D.C.

Harris, L. J. (1978). Sex differences in spatial ability: Possible environmental, genetic, and neurological factors. In M. Kinsbourne (Ed.), Asymmetrical function of the brain. Cambridge: Cambridge University Press.

Harshman, R. A., Remington, R., & Krashen, S. D. (1975). Sex, language, and the brain, Part II: Evidence from

dichotic listening for adult sex differences in verbal lateralization. Unpublished manuscript, University of California, Los Angeles.

Hicks, R. E., & Kinsbourne, M. (1978). Human handedness. In M. Kinsbourne (Ed.), Asymmetrical function of the brain. Cambridge: Cambridge University Press.

Johnson, O., & Harley, C. (1980). Handedness and sex differences in cognitive tests of brain laterality. Cortex, 16, 73-82.

Kimura, D. (1961). Cerebral dominance and the perception of verbal stimuli. Canadian Journal of Psychology, 15, 166-171.

Kimura, D. (1964). Left-right differences in the perception of melodies. Quarterly Journal of Experimental Psychology, 16, 335-358.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. Cortex, 3, 163-178.

Kimura, D. (1973). The asymmetry of the human brain. Scientific American, 228, 70-78.

Kimura, D. (1985). Male brain, female brain: The hidden difference. Psychology Today, 19, 50-58.

Kinsbourne, M. (1970). The cerebral basis of lateral asymmetries in attention. Acta Psychologia, 33,

193-201.

Kinsbourne, M. (1973). The control of attention by interaction between the cerebral hemispheres. In S. Kornblum (Ed.), Attention and performance II. New York: Academic Press.

Kinsbourne, M. (1975). The mechanism of hemispheric control of the lateral gradient of attention. In P. M. A. Rabbit & S. Dornic (Eds.), Attention and performance V. New York: Academic Press.

Kinsbourne, M. (1978). Asymmetrical function of the brain. Cambridge: Cambridge University Press.

Knox, A. W., & Boone, D. R. (1970). Auditory laterality and tested handedness. Cortex, 7, 164-173.

Knox, C. & Kimura, D. (1970). Cerebral processing of nonverbal sounds in boys and girls. Neuropsychologia, 8, 227-237.

Lake, D., & Bryden, M. (1976). Handedness and sex differences in hemispheric asymmetry. Brain and Language, 3, 266-282.

Levy, J. (1969). Possible basis for the evolution of lateral specialization of the human brain. Nature, 224, 614-615.

Levy, J. (1972). Lateral specialization of the human

brain: Behavioral manifestations and possible evolutionary basis. In J. A. Kiger (Ed.), The biology of behavior. Corvallis: Oregon State University Press.

Levy, J. (1976). Cerebral lateralization and spatial ability. Behavior Genetics, 6, 171-188.

Levy, J., & Reid, M. (1978). Variations in cerebral organization as a function of handedness, hand posture in writing, and sex. Journal of Experimental Psychology: General, 107, 119-144.

McGlone, J. (1980). Sex differences in human brain asymmetry: A critical survey. Behavioral and Brain Sciences, 3, 215-163.

McGlone, J., & Davidson, W. (1973). The relationship between cerebral speech laterality and spatial ability with special reference to sex and hand preference. Neuropsychologia, 11, 105-113.

Miller, E. (1971). Handedness and the pattern of human ability. British Journal of Psychology, 62, 111-112.

Nagae, S. (1983). Development of hand-eye dominance in relation to verbal self-regulation of motor behavior. American Journal of Psychology, 96, 539-552.

Nagae, S. (1985a). Handedness and sex differences in the

processing manner of verbal and spatial information. American Journal of Psychology, 98, 409-420.

Nagae, S. (1985b). Handedness and sex differences in selective interference of verbal and spatial information. Journal of Experimental Psychology: Human Perception and Performance, 11, 346-354.

Nebes, R. D. (1971). Handedness and the perception of part-whole relationships. Cortex, 7, 350-356.

Nebes, R. D. , & Briggs, G. G. (1974). Handedness and the retention of visual materials. Cortex, 10, 209-214.

Newcombe, F., & Ratcliff, G. (1973). Handedness, speech lateralization, and ability. Neuropsychologia, 11, 399-407.

Newcombe, F. G., Ratcliff, G. G., Carrivick, P. J., Hiorns, R. W., Harrison, G. A., & Gibson, J. B. (1975). Hand preference and I. Q. in a group of Oxfordshire villages. Annals of Human Biology, 2, 235-242.

Sanders, B., Wilson, J. R., & Vandenberg, S. G. (1982). Handedness and spatial ability. Cortex, 18, 79-90.

Satz, P., Achenbach, K., Patishall, E., & Fennel, E. (1965). Ear asymmetry and handedness in dichotic listening. Cortex, 1, 377-396.

Thistle, A. (1975). Performance of males and females on a dichotic listening task. Journal of the Acoustical Society of America, 58, S76.

Waber, D. P. (1976). Sex differences in cognition: A function of maturation rate? Science, 192, 572-574.

Weber, A. M., & Bradshaw, J. L. (1981). Levy and Reid's neurological model in relation to writing hand/posture: An evaluation. Psychological Bulletin, 90, 74-88.

Witelson, S. F. (1980). Neuroanatomical asymmetry in left-handers: A review and implications for functional asymmetry. In J. Herron (Ed.), Neuropsychology of left-handedness. New York: Academic Press.

Yen, W. M. (1975). Independence of hand preference and sex-linked genetic effects on spatial performance. Perceptual and Motor Skills, 41, 311-318.

Table 1

Mean Number Correct Responses as a Function of Sex and Type of Instructions

	Instructions	
Sex	Left Ear	Right Ear
Male	32.27	43.95
Female	28.85	30.28

Note. Maximum possible number correct for each ear = 60.00.